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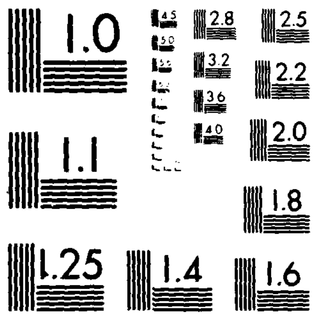

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Multiattribute Risky Choice Behavior:

The Editing of Complex Prospects

John W. Payne, Dan J. Laughhunn

Roy Crum

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This investigation draws upon concepts from prospect theory [8] and multiattribute utility theory [10] in an examination of the multiattribute risky choice behavior of 128 managers. The question of how managers code multiattribute prospects, and how coding relates to various independence assumptions, was explored. Results indicate that managers violate attribute independence in its general form, an[illegible] in the form of the marginality assumption. The most common form of

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behavior was multiattribute risk aversion for prospects involving only gains and multiattribute risk seeking for prospects involving only losses. This result reinforces the importance of a target, reference point, or aspiration level that has been found in studies of single attribute risky choice. Furthermore, the result casts doubt on such commonly used multiattribute utility functions as the additive, multiplicative, and multilinear forms. Event independence, necessary for expectation models and a consequence of the cancellation of common components of prospects, was found to hold when the common values and probabilities were relatively small. When the common event had relatively large values and probabilities, there was some evidence that such events may influence choice. The implications of the results for the development of multiattribute risky decision aids are discussed.

1. INTRODUCTION

Most definitions of a decision problem include: (1) the courses of action or alternatives among which one must choose, (2) the possible outcomes and values attached to them, conditional on the actions, and (3) the contingencies or conditional probabilities that relate outcomes to action [7], [16]. Extensive research exists on how individuals judge the attractiveness of outcomes defined on multiple attributes under the assumption that outcomes are certain. The additive utility model has been most often investigated in this context, although noncompensatory models have also been examined. Extensive research also exists on how individuals decide among alternatives when possible outcomes are defined on only a single attribute, most frequently a monetary attribute, but where the particular outcome to be received is uncertain. The standard model of choice among such risky options is the expected utility model, while the best known alternative to that model is prospect theory [8], [16].

Many of the most important decision problems facing managers, however, involve both risk and multiattribute outcomes (see Bell, Keeney, & Raiffa, [1], for examples). Research on how such decisions are made is much less extensive. Some normative theory does exist [6], [10] with the best known model combining the expected utility principle with an additive utility function. Experimental studies of risky choice behavior with multiattribute outcomes, on the other hand, are quite limited in number and scope (see von Winterfeldt, [17], for a review). Previous experimental studies, for example, have been based on very small samples and have primarily used students and university faculty members as subjects.

The present paper examines the multiattribute risky choice behavior of 128 professional managers. The investigation draws upon concepts from Tversky

and Kahneman's work on decision framing and prospect theory, as well as some of the standard concepts from multiattribute utility theory [10]. The paper is organized as follows. First, those aspects of prospect theory and multiattribute utility theory that are relevant to this paper are briefly discussed, along with results from previous studies of risky choice behavior. Next, the results of our study are presented and the relationship of these results to models of decision making under conditions of risk and multi-attribute outcomes are discussed. The paper concludes with a brief discussion of the implications of the empirical evidence for the development of decision aids.

2. BACKGROUND

The theory of choice introduced by Kahneman and Tversky [8], called prospect theory, is proposed as an alternative to expected utility theory in its traditional form. Prospect theory distinguishes between two phases of the choice process: an initial phase in which the decision problem is edited into a simpler representation in order to make the subsequent phase of evaluation easier for the decision maker. Included in the first phase are editing operations such as coding and cancellation. Coding refers to the perception by a decision maker of each of the gamble outcomes as being either a gain or a loss, with a gain or loss defined relative to a reference point or level of aspiration. In general, it is assumed that the value function used in the evaluation of coded outcomes will be concave for gains, convex for losses, and steeper for losses than for equivalent gains. The essence of the editing operation of cancellation is the discarding of components that are common to the offered gambles. According to Kahneman and Tversky [8], for example, the following choice between the gambles ($200, .2; $100, .5; -$50, .3) and (200, .2; $150, .5; -$100, .3) would first be simplified by cancellation of the

common outcome-probability pair (\$200, .2) to a choice between (\$100, .5; -\$50, .3) and (\$150, .5; -\$100, .3). More generally, the editing operations of coding and cancellation are part of what Tversky and Kahneman [16] refer to as the "framing of decisions." A decision frame refers to a decision-makers' perception of the alternatives, outcomes, and contingencies associated with a particular decision problem.

Research on prospect theory has focused on explaining choice among single attribute gambles. There is substantial empirical evidence supporting various aspects of prospect theory for one attribute [8], [12], [13], [14], and [16]. However, in their paper on the framing of decisions, Tversky and Kahneman [16] introduced concepts that can be used to extend prospect theory to problems involving multiattribute risky choice. They defined, for example, the concept of a "compound outcome" as one that joins a series of changes in a single attribute, such as a sequence of yearly cash flows, or a set of concurrent changes in several attributes. Multiattribute risky choice can therefore be thought of as selection among prospects with compound outcomes. Furthermore, Tversky and Kahneman suggested that a useful concept for describing the evaluation of compound outcomes is the notion of a "psychological account." A psychological account "...specifies (i) the set of elementary outcomes that are evaluated jointly and the manner in which they are combined and (ii) a reference outcome that is considered neutral or normal [p. 456]." The question of how elementary outcomes are evaluated jointly is, of course, at the heart of multiattribute utility theory. At present, there is no empirical evidence with respect to the editing operations of coding and cancellation, or on more general features of decision framing, in the multiattribute case.

There is a substantial theoretical literature devoted to the development of utility models that can be used to represent preferences for multiattribute

gambles (see Farquhar, [3], for a review). According to von Winterfeldt [17], two independence assumptions can be used to distinguish among the various models of multiattribute risky preference: event independence and attribute independence. These two forms of independence, and their relationships to the coding and cancellation operations of prospect theory, can be illustrated by the following pair of two outcome, two attribute gambles:

		Gamble 1		Gamble 2			
		Events		Events			
		$p_1(E_1)$	$p_1(E_2)$	$p_2(E_1)$	$p_2(E_2)$		
Attributes	A_1	a	b	e	f	A_1	Attributes
	A_2	c	d	g	h	A_2	

In these gambles, a, b, c, d, e, f, g, and h are the outcome values associated with the alternatives on the two attributes A_1 and A_2, conditional on the events E_1 and E_2. Gamble 1 (denoted G1) provides two joint outcome possibilities: a and c if E_1 occurs or b and d if E_2 occurs. The probabilities for these two joint outcomes are $p_1(E_1)$ and $p_1(E_2)$ respectively, with both probabilities positive and where $P_1(E_1) + P_1(E_2) = 1$. A similar interpretation applies to Gamble 2 (denoted G2).

According to event independence, preference between two arbitrary multiattribute gambles with identical multiattribute outcomes and probabilities for a particular event E_j, e.g., $P_1(E_2) = P_2(E_2)$ and b=f, d=h, should remain the same no matter what values are assigned to the multiattribute outcomes (b, f, d & h), provided that the original equalities hold. Event independence is a necessary condition for the expected utility model. Event independence would follow from the editing operation of cancellation in prospect theory. The editing operation implies that a decision maker will cancel from consideration any common joint outcome that has the same probability in both gambles.

According to attribute independence, preference between two multiattribute gambles which are arbitrary except for identical single attribute gambles over a particular attribute A_i, i.e., identical marginal probability distributions over the attribute, should remain the same no matter what the marginal probability distributions of the gamble on A_i. In its most general form, attribute independence is consistent with a cancellation type of editing operation. As pointed out by von Winterfeldt [17], a multiattribute gamble can be thought of as an ensemble of multiattribute outcomes (conditional on events) or as an ensemble of single attribute gambles (conditional an attributes). Attribute independence implies that single attribute gambles that are shared by multiattribute options will not affect preferences, i.e., the common single attribute gambles will be discarded or ignored.

A special form of attribute independence, called the marginality assumption, states that preferences between gambles with identical marginal distributions on all attributes are unaltered if the marginal distributions change but remain identical. As an example, the marginality assumption implies indifference between the following two gambles:

	Gamble 1		Gamble 2	
	.5	.5	.5	.5
A_1	x	0	x	0
A_2	0	y	y	0

The marginality assumption, also called value independence, is a necessary condition for the expected utility model with an additive function over the attributes. The marginality assumption is consistent with a form of editing whereby the joint probability distribution on the two attributes is reduced to two marginal probability distributions for decision making purposes. Simultaneous occurrences for the two attributes are unimportant and eliminated from

consideration if the marginality assumption holds.

Fishburn [5] and Richards [15] have used preference between two gambles with identical marginal probability distributions on the attributes to define a concept of multivariate risk preferences. A decision maker who prefers G1 to G2 exhibits pairwise multivariate risk aversion. On the other hand, a decision maker who prefers G2 to G1 exhibits multivariate risk seeking. Indifference between G1 and G2 indicates that a decision maker is multivariate risk neutral. While multivariate risk attitudes intuitively seem to reflect behavior akin to classical single attribute risk attitudes, multivariate risk preferences are an independent construct. That is, risk preferences over a single attribute do not imply anything about the risk preferences for the joint probability distribution over the various combinations of the levels of different attributes.

More generally, Fischer and Kamlet [4] show that strict multivariate risk aversion (SMRA), strict multivariate risk neutrality (SMRN), or strict multivariate risk seeking (SMRS) is a necessary condition for any utility model that decomposes the utility of the joint outcomes into a function (additive, multiplicative, or multilinear) of single attribute utilities.

Another special form of attribute independence that is often used to identify an appropriate utility function is utility independence. Utility independence requires attribute independence to hold only if the gamble on the attribute for both options is a surething, i.e., if the marginal probability distribution is degenerate. The property of utility independence is a necessary and sufficient condition for the existence of a single utility function over one of the attributes [10].

As noted earlier, the number of empirical studies of multiattribute risk preferences is quite limited. The most extensive experimental study to date

is by von Winterfeldt [17]. In that study, which involved only gains on the attributes, 18 university students and staff members were asked to indicate preferences among 50-50 gambles for commodity bundles containing certain amounts of ground beef and gasoline. In general, event independence was found to hold for the simple 50-50 gambles used in that study. On the other hand, the marginality form of attribute independence was systematically violated. Sixteen of the 18 subjects exhibited multivariate risk aversion. Von Winterfeldt interpreted this result as showing that subjects preferred "...the gamble in which they could win something in each event over the gamble in which they could win a lot in one event and nothing in the other [17, p. 80]." Furthermore, von Winterfeldt reported that multivariate risk preferences were independent of single attribute risk preferences and of the willingness of the decision makers to make tradeoffs in a riskless case.

Additional evidence for multivariate risk aversion in the gain region is provided by Krzystofowicz and Duckstein [11]. In a study of 12 subjects (6 hydrologists and 6 graduate students), the found that 9 out of 12 subjects exhibited multivariate risk aversion when asked to choose between a pair of 50-50, two-attribute gambles.

While experimental studies of multivariate risk taking are limited, there are many studies of risk preferences among single attribute gambles. Recently, several such studies indicate that preferences among univariate gambles are most frequently risk averse for gains and risk seeking for (non-ruinous) losses. For example, Kahneman and Tversky [8] report that the gamble which provides a chance to win $3000 with probability 0.9 or to win nothing with probability 0.1, denoted ($3000, .9), is usually chosen over the gamble ($6000, .45), a result which implies a concave utility function or risk aversion. On the other hand, the gamble (-$6000, .45) is usually chosen over

the gamble (-$3000, .9), a result which implies a convex utility function or risk seeking. Kahneman and Tversky refer to the above pattern of choices as the "reflection effect." Payne, Laughhunn, and Crum [13] confronted managers with a choice between the gamble that has a 0.5 chance of returning $14,000, a 0.1 chance of returning -$30,000, and a 0.4 chance of returning -$85,000, represented ($14, .5; -$30, .1; -$85, .4) and denoted GI, and the gamble given by (-$20, .3; -$30, .5; -$45, .2), denoted GII. In this case, 67 percent of the subjects chose GI. However, when the gambles GI and GII were transformed by adding $60,000 to all outcomes to create new gambles GI' and GII', denoted ($74, .5; $30, .1; -$25, .4) and ($40, .3; $30, .5; $15, .2), approximately 83 percent of the subjects chose GII'. According to Payne et. al., the key determinant of the effect of the translation of outcomes (adding a constant) was whether the size of the translation was sufficient to result in one gamble having outcome values either all above or all below a reference point or target, while the other gamble had outcome values that are both above and below the reference point. The result discussed above supports the need to incorporate a reference point, target level, or aspiration level concept in the analysis of risky choice behavior. More specifically, the results support the existence of a coding operation in the editing of single attribute gambles that transforms outcome into gains and losses.

The following experiment examines the hypothesis that multivariate risk preferences will be a function of whether the outcomes are gains or losses. If true, a reversal in multivariate risk attitudes has important implications for the appropriate form of a multiattribute utility model. In addition, the experiment examines the concepts of event independence, attribute independence, utility independence, and more generally, the methods that individuals use to code multiattribute risky gambles.

3. EXPERIMENT RESULTS

Method

The subjects were 128 managers from a variety of U.S. business firms: 46 from two telecommunications companies, 29 from a large electronics manufacturer, and 53 from a broad cross section of industry. All of the participating managers had fifteen or more years of experience and held administrative positions ranging from middle manager to president. Thirty eight of the managers were in senior positions (vice president or above).

The stimuli were pairs of hypothetical capital budget proposals. All managers in the sample either had current or previous responsibility for various respects of capital budgeting for their firms. By advance instruction (both written and oral), the managers were told that they would be presented with a series of pairs of mutually exclusive capital projects to choose from. For each pair, they were asked to choose the project that they would prefer to implement on behalf of their company. The managers were informed that all pairs of projects should be considered equivalent from an overall profitability viewpoint and from the viewpoint of strategic considerations. The managers were also asked to assume that there were no constraints, financial or otherwise, that would limit their ability to freely choose among the projects. For their decisions, the managers were asked to focus on differences between the projects in terms of two attributes: net cash flow in year 1 and net cash flow in year 2. In this decision context, zero is a natural target level for both attributes, with positive cash flows being desireable outcomes and negative cash flows being undesireable. Net cash flows were used as the two attributes because the managers participating in the experiment were generally familiar with the concept, because net cash flows are important in assessing the short-term impact of capital spending [2] and because net cash cash flows

can be either positive or negative. In addition, Fishburn [6], among others, has represented such intertemporal decision problems as problems involving multiattribute risky choice.

Some of the pairs of projects involved two outcomes and some involved three. The choice problems were presented to the managers in a booklet, with each choice problem on a separate page. The sets of two-outcome gambles and three-outcome gambles were presented in separate parts of the booklet. Within each part, however, the ordering of the choice problems was randomized and the position of the projects on a page was counterbalanced. Fifty-three of the managers were presented with 24 pairs of projects and 75 were presented with between 26 and 28 pairs. Each manager was given ample time to respond. Between 40 and 60 minutes were required by managers to complete the task.

Results

Tests of the Attribute Independence and Editing. As has been found by other investigators, the predominant pattern of preference for multiattribute gambles with positive outcomes is risk aversion. Results of the present study are consistent with this pattern, as the following pairs of choice problems demonstrate. The dollar amounts are in thousands of dollars. The number of managers responding to each choice problem is denoted by N, while the percentage who choose each gamble is given in the brackets immediately below the gambles.

Problem 1: Choose between (N = 53)

	Gamble 1		Gamble 2	
	.5	.5	.5	.5
Cash flow Year 1	$20	$0	$0	$20
Cash flow Year 2	$0	$20	$0	$20
	[74]		[26]	

Problem 2: Choose between (N = 75)

	Gamble 1		Gamble 2	
	.5	.5	.5	.5
Cash flow Year 1	$75	$0	$75	$0
Cash flow Year 2	$0	$200	$200	$0
	[53]		[47]	

The similarity of the present results with the findings of other investigators [11], [17] who used other kinds of attributes is encouraging. These results suggest that, when confronted with multiattribute gambles involving only gains, managers prefer those gambles that have balanced outcome possibilities across the attributes, rather than gambles which provide all or nothing possibilities.

However, as the responses to the following pairs of gambles indicate, when the attributes assumed negative values, the managers generally exhibited multivariate risk seeking. These responses are from the same subjects who indicated risk aversion for gains. For all 128 managers, the differences in the percentage of managers choosing GI in problems 1 and 2 relative to problems 3 and 4 is statistically significant based on a matched pair t-test ($t = 3.33$, $p < .01$).

Problem 3: Choose between (N = 53)

	Gamble 1		Gamble 2	
	.5	.5	.5	.5
Cash flow Year 1	-$20	$0	$0	-$20
Cash flow Year 2	$0	-$20	$0	-$20
	[45]		[55]	

Problem 4: Choose between (N = 75)

	Gamble 1		Gamble 2	
	.5	.5	.5	.5
Cash flow Year 1	-$75	$0	-$75	$0
Cash flow Year 2	$0	-$200	-$200	$0
	[37]		[63]	

Faced with only negative cash flow possibilities, or at best zero cash flows, apparently the desire of managers to achieve both target levels simultaneously was a strong enough motivating factor to induce a majority of them to choose gambles with all or nothing outcomes on both attributes.

An analysis of the patterns of choice for each individual manager confirms the reversal in multiattribute risk attitudes. For the entire group of 128 managers, 62% were risk averse for gains and 59% were risk seeking for losses. The most common pattern of choice, for 33% of the managers, involved the predicted reversal: from the risk averse gamble (G1) for gains to the risk seeking gamble (G2) for losses. A test of the equality of two correlated proportions, applied to those patterns of choice involving a shift in choice, showed a significant difference ($\chi^2(1) = 11.86$, $p < .001$).

In addition to tests of the marginality assumption, choices were obtained

from the managers that allow tests of several other issues concerned with the combination and editing of attribute value information. Some of these choice problems and responses are summarized in Table 1.

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Place Table 1 About Here
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The three choice problems listed in Table 1 (5, 6, & 7) provide a test of attribute independence in a more general form. Note that problem 5 has, for both gambles, the same values for cash flow in year 1 as does problem 1. However, the cash flows in year 2 are reduced for both gambles of problem 5 by a constant amount -\$20. Comparing the responses to problems 1 and 5, it is evident that the translation of outcome values had a significant impact on choice. On an aggregate basis, the percentage of managers choosing G1 declined from 72% in problem 1 to 42% in problem 5, a change which is significant based on a matched pairs t-test ($t = 3.25$, $p < .01$). This aggregate shift is reinforced by an analysis of the within subjects shifts in choice between the two problems ($\chi^2(1) = 10.8$, $p < .01$), with the predominant pattern being a shift from G1 in problem 1 to G2 in problem 5. For problems 6 and 7, the cash flows in year 2 are the same as those in problems 2 and 4, respectively. However, the cash flows in year 1 for problem 6 are reflected from those in problem 2 and the cash flows in year 1 for problem 7 are reflected from those in problem 4. In comparing the responses to problems 2 and 6, choices shifted from mainly multivariate risk aversion (problem 2) to multivariate risk seeking (problem 6), with significance on both an aggregate basis (based on a matched pair t-test, with $t = 2.5$, $p = .02$) and a within subjects basis ($\chi^2(1) = 5.11$, $p < .05$). In contrast, for problems 4 and 7, there was a shift in choice from multivariate risk seeking (problem 4) to multivariate risk aversion (problem 7), again with significance on both an

aggregate basis (based on a matched pair t-test, with $t = 4.8$ and $p < .001$) and on a within subjects basis ($\chi^2(1) = 16.5$, $p < .005$). Taken together, the patterns of responses to the first seven choice problems strongly indicate that attribute independence is generally violated. The results also indicate that decision makers do not edit common single attribute gambles out of multiattribute choice problems.

It is also interesting to compare the pattern of choice for problems 5, 6, and 7. The pattern reinforces the importance of the probability of gain and loss that is stressed in the Payne, Laughhunn, and Crum [13] model of aspiration level effects on risky choice behavior. The results also reinforce the importance of coding. Note that in problem 6, G2 offers a chance of what is likely to be viewed as a positive compound outcome -$75 and $200 with no possibility of a negative compound outcome, whereas G1 offers a chance at either a gain or a loss. The majority of preferences are for G2. In problem 5, G2 again offers a possible positive compound outcome $0 and $20, but also a possible compound loss outcome $0 and -$20. In constrast, G1 offers no outcome that is likely to be viewed as positive and one compound outcome $20 and -$20 that, if the value function for losses is steeper than for gains [8], is likely to viewed as a loss. Again, the majority of preferences are for G2. Finally, note in problem 7 that G1 offers one compound outcome that is positive, $75 and $0, and one that is negative, $0 and -$200, whereas G2 offers no outcome that is likely to be viewed as positive and one compound outcome that is likely to be viewed as negative, $75 and -$200. In this case, the majority of preferences are for G1.

The final results relevant to editing by attribute concerns tests of utility independence. This issue is concerned with whether individuals edit single attribute gambles from multiattribute choice options when gambles are

degenerate, i.e., surethings. The problems used to test utility independence with symmetric gambles, are summarized in Table 2. Consider the responses to

Place Table 2 About Here

problems 8 and 9, which both have the same degenerate marginal distributions for cash flows in year 2. The important difference between the two problems is that problem 8 has an above target surething in year 2, while problem 9 has a below target surething in year 2. The relative choice proportions were the same in both problems, and the number of within subjects shifts in preference was also insignificant ($\chi^2(1) = .1$). Similar insignificant choice patterns, both aggregate and within subjects, were observed for problems 10 and 11 and for problems 12 and 13. These results support utility independence. One exception to this support occurred in problems 14 and 15. For this set of problems, the predominant aggregate choice pattern was strongly in favor of G1 in problem 14 and strongly in favor of G2 in problem 15 (with significance based of G2 in problem 15 on a matched pair t-test, $t = 2.14$ and $p = .05$). This pattern was also verified by a test of within subjects, where the primary pattern was a switch from G1 in problem 14 to G2 in problem 15 ($\chi^2(1) = 3.27$, $p < .10$).

So far, the pairs of choice options that have been discussed all involved symmetric 50-50 gambles. Such gambles have been the focus of previous experimental studies of multiattribute risk taking [11], [17] and have often been suggested as the basic gambles to be used in multiattribute utility analysis [10]. However, research by Karmakar [9], among others, suggests the need to investigate utility independence using nonsymmetric probability distributions over outcomes. Consequently, the choice problems of Table 3 were used for additional tests. Results for these non-symmetric gambles are

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less conclusive abut utility independence. In problems 18 and 19, the pattern of choices contains no significant differences, either on an aggregate basis or within subjects. However, for the remainder of the problems of Table 3, the results relative to utility independence are mixed. For problems 16 and 17 and problems 22 and 23, the differences between the aggregate percentage of choices of G1 are marginally significant ($t = 1.45$, $p = .14$ for problems 16 and 17; $t = 1.47$, $p = .14$ for problems 22 and 23). In spite of these aggregate shifts in choice, there was no significant pattern of shifts on a within subjects basis ($\chi^2(1) = 1.1$ for problems 16 and 17 and $\chi^2(1) = 1.4$ for problems 22 and 23). For problems 20 and 21, on the other hand, there was both a significant difference between the aggregate percentages choosing G1 ($t = 1.97$, $p = .05$) and a significant shift from G2 in problem 20 to G1 in problem 21 ($\chi^2(1) = 2.9$, $p < .10$).

The results for both symmetric and nonsymmetric gambles are not therefore uniformly supportive of utility independence. For symmetric gambles, the weight of the evidence is supportive and indicates a tendency of managers to cancel or edit out common attributes when they are identical surethings in both options. For nonsymmetric gambles on the, other hand, there is at least some evidence to indicate that utility independence may not hold.

<u>Tests of Event Independence and Editing</u>. As noted earlier, event independence is a necessary condition for expected utility models. Event independence has generally been found to hold in previous empirical studies [17]. The present study found that event independence held for a large majority of managers, when the outcome values of the common event and the probabilities were relatively small. To illustrate, consider the responses to the following

choice problems.

Problem 24: Choose between (N = 53)

	Gamble 1			Gamble 2		
	.4	.4	.2	.4	.4	.2
Cash flow Year 1	$20	$0	$10	$0	$20	$10
Cash flow Year 2	$0	$20	$10	$0	$20	$10
		[72]			[28]	

This pattern of choices is consistent with multivariate risk aversion, a result very similar to that obtained for problem 1. That is, the gamble with a sure gain (G1) was preferred. A change in the common event of problem 24 had no significant impact on choice behavior, as indicated by the following problem.

Problem 25: Choose between (N = 53)

	Gamble 1			Gamble 2		
	.4	.4	.2	.4	.4	.2
Cash flow Year 1	$20	$0	-$10	$0	$20	-$10
Cash flow Year 2	$0	$20	-$10	$0	$20	-$10
		[79]			[21]	

Again, the gamble with the more balanced outcomes was preferred, although G1 no longer provides a sure gain.

For this group of 53 managers, there were 12 such problems that could be used to test event independence (see Table 4). These problems are three -

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Place Table 4 About Here

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outcome gambles generated by using three different common events with each of four basic gamble pairs. For each basic gamble pair, the common event was systematically altered by translations so that it was both above and below target on both attributes. One general feature of all of the problems of Table 4 is that the probability of the common event is relatively low and its outcome values are comparable to the outcome values of the non-common events.

The aggregate percentage of managers choosing G1 for each problem is also provided in Table 4. These data indicate very little change in the percentage of G1 choices within each basic gamble pair. None of the percentages were statistically different for any two problems within each gamble pair. In addition, none of the within subjects shifts in preference was significant for any two problems. Event independence held for these managers regardless of whether the common event was above or below target on both attributes. Furthermore, the impact of event independence on choice behavior did not appear to be influenced by whether other events (non-common) had outcome values that were above or below target or whether the probability values on other events were identical or different across the gambles. Overall, the choice patterns in Table 4 suggest that cancellation of the common event occurs prior to the coding of outcomes into gains and losses.

Table 5 shows the values of four additional gambles pairs that were

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designed to further test event independence with 75 different managers. These pairs of gambles were constructed so that the common events would have the largest probability-outcome values within the gambles. The hypothesis was that the relative size of the common event values would increase the salience of that event and therefore reduce the likelihood that the event would be

edited out or cancelled. The choice percentages for G1 given in Table 5 are significantly different within each gamble pair ($t = 2.47$, $p = .02$ for problems 36 and 37 and $t = 2.12$, $p = .04$ for problems 38 and 39).

A count of the number of within subjects in preference, for problems 36 and 37 and problems 38 and 39, are given in Tables 6a and 6b, respectively. Table 6a indicates a significant shift in choice from G2 in problem 37 to G1

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Place Table 6a and 6b About Here
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in problem 36 ($\chi^2(1) = 4.92$, $p < .05$), while Table 6b indicates a less significant shift of the same type ($\chi^2(1) = 3.68$, $p < .10$). These results indicate that event independence may be violated when the common event has relatively large probability and outcome values.

More research is needed to better understand when event independence may be violated. However, the overall pattern of results obtained in the present study indicates that event independence is less likely to be violated than the various forms of attribute independence.

4. SUMMARY AND CONCLUSIONS

This paper has provided empirical evidence about the multiattribute risky choice behavior of 128 managers. The primary concern of the experiment was to investigate how managers code multiattribute risky options and to relate the coding operations to various independence assumptions of multiattribute utility theory.

Results of the experiment indicate that managers violated attribute independence in its general form and did not code common attributes out of gambles. In addition, managers violated the marginality assumption, a special case of attribute independence. The type of violation observed was that a

majority of managers were risk-averse when the gamble involved only gains on the attributes, while a majority of managers were risk-seeking when the gambles involved only losses. The most common form of behavior (for 33% of the managers) was multiattribute risk aversion for gains and multiattribute risk-seeking for losses. This result reinforces the existence of a coding operation for outcomes relative to a target level of return and supports a form of multiattribute risky choice behavior akin to the reflection effect of prospect theory. The empirical evidence also supports the conclusion that managers do not code multiattribute risky options by reducing the joint probability distributions over attributes to marginal distributions on the individual attributes. Joint outcomes and probabilities of joint outcomes appear to be related to choice behavior.

The experimental results provide mixed support for the existence of utility independence and the corresponding coding operation of discarding attributes when they are of equal value and degenerate in both gambles. This form of behavior was observed for symmetric gambles, with one exception, regardless of whether the sure-thing outcome was above or below the target level of return. For nonsymmetric gambles, the results cast some doubt on whether utility independence holds.

Event independence was also strongly supported by the experiment when the common outcome value and associated probabilities were relatively small. This result held regardless of whether the common event was at or below target, whether the non-common events were at or below target, or whether the probability distributions were symmetrical or non-symmetrical. The only exception to the conclusion about event independence was for those circumstances where the common event had relatively large outcome values and relatively large probabilities of occurring. In this case, there is some

evidence to indicate that such events may not be coded out of gambles. The pattern of shifts in choice by the managers were significant for this case. A possible explanation for the possible violation of event independence for this situation, while not present in the case where the common event and probability were low, is that the coding of outcomes onto gains and losses may precede the coding operation of cancellation. The prior coding of large outcomes into gains and losses may increase the salience of these outcomes to such an extent that the subsequent operation of cancellation is not performed. For this case, the common event may not be discarded as irrelevant to choice behavior.

There are several factors that limit the generality of the conclusions in this study. First, the 128 managers who voluntarily participated in this study were not selected at random, but were chosen based on the willingness of their firms to cooperate in the experiment. Within the cooperating firms, attempts were made to obtain managers for the experiment who had authority to make decisions which committed significant corporate resources and who had current or previous experience with the capital budgeting process. This factor raises the obvious question about the generality of the empirical results for the larger population of professional managers. Second, the participation of firms and managers was obtained on a condition that the experiment would not create an excessive time commitment away from normal busines activities. The experiment was therefore designed to take approximately one hour in total time. A time limitation imposed a contraint on the number of choice problems that could be given to each manager and hence prevented a single set of questions for all managers. Third, the experiment used a capital budgeting context and two attributes (cash flows in the first two years) that are important and were well known by the participating managers. A remaining question about the experiment is whether the empirical

findings will hold if a different context and/or different attributes are utilized. These limitations suggest that additional empirical research will be required before the weight of the present research findings can be put in proper perspective. However, the fact that some of the empirical findings (particularly for event independence and multiattribute risk aversion for gains) are consistent with earlier studies provide at least a preliminary benchmark for the importance of the experimental results.

Collectively, the results of this experiment have implications for the forms of plausible multiattribute utility functions. Since event independence generally held, the results support the validity of the expected utility model. The exception to this support occurred for the case where the salience of common events apparently precluded cancellation. The results are inconsistent, however, with some of the specific functions forms that have been suggested for translating expected utility theory into operational models.

The most commonly used functional forms are additive, multiplicative, and multilinear. The present study casts serious doubts on all three of these forms. As currently developed all three forms ignore the possible existence of a target level for the individual attributes, the coding of outcomes into gains and losses based on targets, and the differences in risk attitudes when outcomes fall above or below target. The present study, coupled with similar empirical research for the single attribute case, indicates that a single functional form (of any of the three types) for both the positive and negative domains is likely to be inadequate. In fact, a recent paper by Fischer and Kamlet [4] shows that multiattribute risk seeking for losses and multiattribute risk aversion for gains -- one of the empirical findings of this paper -- renders all three forms incapable by representing such preferences.

As an alternative formulation, Fischer and Kamlet [4] propose a new

model, called a reference risk-value (RRV) model. The RRV model was proposed by Fischer and Kamlet to meet two criteria: (1) to reflect the qualitative and quantitative properties of a decision maker's preferences and (2) to allow simplicity in structure and assessment processes. These two criteria are important conditions if there is to be progress in developing decision aids for managers in the multiattribute case. The RRV model, which includes targets and the coding of outcome relative to targets, is capable of incorporating multiattribute risk seeking for losses and multiattribute risk aversion for gains. The model is also capable of modelling reference effects on an attribute-by-attribute-basis or by using a riskless value associated with a reference outcome. The RRV model is consistent with the empirical results of this paper and hence appears to meet the first criterion for a model in the multiattribute case. In particular, the RRV model appears to be consistent with the types of coding operations that managers utilize when evaluating multiattribute risky choices. The exception to this support is the possible non-cancellation of salient common events which is a necessary ingredient of all expected utility models. More systematic studies of events independence for this questionable case is needed, however, before a definitive judgment can be made about the conditions where the coding of common events by cancellation may not occur. At the present time, the RRV model -- as an alternative to standard approaches -- appears to be a relatively simple and promising structure for translating the expected utility principle into operationally useful decision aids.

Table 1

Tests of Attribute Independence[1]

	Problem 5(N = 53)				Problem 6(N = 75)				Problem 7(N = 75)			
	G1		G2		G1		G2		G1		G2	
	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
A_1	$20	$0	$0	$20	-$75	$0	-$75	$0	$75	$0	$75	$0
A2	-$20	$0	-$20	$0	$ 0	$200	$200	$0	$0	-$200	-$200	$0
	[42]		[58]		[40]		[60]		[73]		[27]	

[1] Outcome values are in thousands of dollars.

Table 2

Tests of Utility Independence with Symmetric Gambles[1]

Problem 3 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	$50	$30	$70	$10
A_2	$150	$150	$150	$150
	[46]		[54]	

Problem 9 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	$50	$30	$70	$10
A_2	-$150	-$150	-$150	-$150
	[46]		[54]	

Problem 10 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	$60	$60	$60	$60
A_2	$150	$150	$150	$150
	[41]		[59]	

Problem 11 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	-$60	-$60	-$60	-$60
A_2	$20	$140	$60	$100
	[51]		[49]	

Problem 12 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	-$50	-$30	-$70	-$10
A_2	-$150	-$150	-$150	-$150
	[64]		[36]	

Problem 13 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	-$50	-$30	-$70	-$10
A_2	$150	$150	$150	$150
	[57]		[43]	

Problem 14 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	-$60	-$60	-$60	-$60
A_2	-$20	-$140	-$ 60	-$110
	[67]		[43]	

Problem 15 (N = 28)

	G1		G2	
	.5	.5	.5	.5
A_1	$60	$60	$60	$60
A_2	-$20	-$140	-$60	-$100
	[43]		[57]	

[1] Outcomes values are in thousands of dollars.

Table 3

Tests of Utility Independence with Nonsymmetric Gambles[1]

Problem 16 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	$60	$60	$60	$60
A_2	$100	$100	$100	$100
	[71]		[29]	

Problem 17 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	$60	$0	$0	$180
A_2	-$100	-$100	-$100	-$100
	[57]		[43]	

Problem 18 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	$55	$55	$55	$ 55
A_2	$40	$0	$0	$120
	[54]		[46]	

Problem 19 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	-$55	-$55	-$55	-$55
A_2	$40	$0	$0	$120
	[61]		[39]	

Problem 20 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	-$60	$0	$0	-$180
A_2	-$100	-$100	-$100	-$100
	[32]		[68]	

Problem 21 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	-$60	$0	$0	-$180
A_2	$100	$100	$100	$100
	[57]		[43]	

Problem 22 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	-$55	-$55	-$55	-$55
A_2	-$40	$0	$0	-$120
	[46]		[54]	

Problem 23 (N = 28)

	G1		G2	
	.75	.25	.75	.25
A_1	$55	$55	$55	$55
A_2	-$40	$0	$0	-$120
	[64]		[36]	

[1]Outcomes values are in thousands of dollars.

Table 4

Tests of Event Independence[1]
(N = 53)

Basic Gamble Values for Problems 24, 25 and 26

	G1			G2				P(G1)[2]
	.4	.4	.2	.4	.4	.2	Problem 24: x=y= $10	.72
A_1	$20	$0	x	$0	$20	x	Problem 25: x=y=-$10	.79
A_2	$0	$20	y	$0	$20	y	Problem 26: x=y= $30	.72

Basic Gamble Values for Problems 27, 28 and 29

	G1			G2				P(G1)
	.4	.4	.2	.4	.4	.2	Problem 27: x=y=-$10	.60
A_1	-$20	$0	x	$0	-$20	x	Problem 28: x=y= $10	.53
A_2	$0	-$20	y	$0	-$20	y	Problem 29: x=y=-$30	.58

Basic Gamble Values for Problems 30, 31 and 32

	G1			G2				P(G1)
	.6	.1	.3	.5	.2	.3	Problem 30: x=y= $45	.79
A_1	$10	$0	x	$0	$30	x	Problem 31: x=y= $ 5	.79
A_2	$0	$40	y	$0	$20	y	Problem 32: x=y=-$35	.81

Basic Gamble Values for Problems 33, 34 and 35

	G1			G2				P(G1)
	.6	.1	.3	.5	.2	.3	Problem 33: x=y=-$45	.34
A_1	-$10	$0	x	$0	-$30	x	Problem 34: x=y=-$ 5	.32
A_2	$0	-$40	y	$0	-$30	y	Problem 35: x=y= $35	.34

[1] Outcome values are in thousands of dollars.
[2] Proportion of managers choosing gamble G1.

Table 5

Further Tests of Event Independence
With Larger Values for the Common Events[1]
(N = 75)

Basic Values for Gamble Pairs 36 and 37

	G1			G2				$P(G1)$[2]
	.2	.2	.6	.2	.2	.6	Problem 36: x=y= $80	.52
A_1	\$50	\$0	x	\$0	\$50	x	Problem 37: x=y=-\$80	.64
A_2	\$0	\$50	y	\$0	\$50	y		

Basic Values for Gamble Pairs 38 and 39

	G1			G2				P(G1)
	.2	.2	.6	.2	.2	.6	Problem 38: x=y=-\$80	.47
A_1	-\$50	\$0	x	\$0	-\$50	x	Problem 39, x=y= \$80	.60
A_2	\$0	-\$50	y	\$0	-\$50	y		

[1] Outcome values are in thousands of dollars.
[2] Proportion of choices of gamble G1.

Table 6a

Pattern Of Within Subject Choices
For Problems 36 and 37

		Problem 37	
		G1	G2
Problem 36	G1	37[1]	2
	G2	11	25

Table 6b

Pattern Of Within Subject Choices
For Problem 38 and 39

		Problem 39	
		G1	G2
Problem 38	G1	29[1]	6
	G2	16	24

[1]Entries indicate the number of subjects choosing the indicated combination of gambles in the two problems.

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FOOTNOTES

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Training Analysis and Evaluation
Group
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Combat Control Systems
Naval Underwater Systems Center
Newport, RI 02840

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Naval Postgraduate School
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Code 8231
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San Diego, CA 92152

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Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
Code RD-1
Washington, D.C. 20380

Mr. Arnold Rubinstein
Naval Material Command
NAVMAT 0722 - Rm. 508
800 North Quincy Street
Arlington, VA 22217

Commander
Naval Air Systems Command
Human Factors Programs
NAVAIR 340F
Washington, D.C. 20361

CDR Robert Biersner
Naval Medical R&D Command
Code 44
Naval Medical Center
Bethesda, MD 20014

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Behavioral Sciences Department
Naval Medical Research Institute
Bethesda, MD 20014

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Naval Health Research Center
San Diego, CA 92152

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Submarine Medical Research Lab
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Head
Aerospace Psychology Department
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Pensacola, FL 32508

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Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

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Human Factors Engineering Division
Naval Air Development Center
Warminster, PA 18974

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Monterey, CA 93940

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5001 Eisenhower Avenue
Alexandria, VA 22333

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Systems Research Laboratory
U.S. Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

U.S. Air Force Office of Scientific
Research
Life Sciences Directorate, NL
Bolling Air Force Base
Washington, D.C. 20332

Chief, Systems Engineering Branch
Human Engineering Division
USAF AMRL/HES
Wright-Patterson AFB, OH 45433

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Dr. Earl Alluisi
Chief Scientist
AFHRL/CCN
Brooks AFB, TX 78235

Dr. Kenneth Gardner
Applied Psychology Unit
Admiralty Marine Technology
Establishment
Teddington, Middlesex TW11 OLN
ENGLAND

Director, Human Factors Wing
Defence & Civil Institute of
Environmental Medicine
Post Office Box 2000
Downsview, Ontario M3M 3B9
CANADA

Dr. A. D. Baddeley
Director, Applied Psychology Unit
Medical Research Council
15 Chaucer Road
Cambridge, CB2 2EF
ENGLAND

Defense Technical Information Center
Cameron Station, Bldg. 5
Alexandria, VA 22314 (12 cys)

Dr. Judith Daly
System Sciences Office
Defense Advanced Research Projects
Agency
1400 Wilson Blvd
Arlington, VA 22209

Dr. Robert R. Mackie
Human Factors Research, Inc.
5775 Dawson Avenue
Goleta, CA 93017

Dr. Gary McClelland
Institute of Behavioral Sciences
University of Colorado
Boulder, CO 80309

Dr. Jesse Orlansky
Institute for Defense Analyses
400 Army-Navy Drive
Arlington, VA 22202

Dr. T. B. Sheridan
Department of Mechanical Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Dr. Paul Slovic
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Harry Snyder
Department of Industrial Engineering
Virginia Polytechnic Institute and
State University
Blacksburg, VA 24061

Dr. Amos Tversky
Department of Psychology
Stanford Unversity
Stanford, CA 94305

Dr. W. S. Vaughan
Oceanautics, Inc.
422 6th Street
Annapolis, MD 21403

Dr. Robert T. Hennessy
NAS - National Research Council
2101 Constitution Ave., N.W.
Washington, DC 20418

Dr. M. G. Samet
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Robert Williges
Human Factors Laboratory
Virginia Polytechnic Institute
and State University
130 Whittemore Hall
Blacksburg, VA 24061

Dr. Alphonse Chapanis
Department of Psychology
The Johns Hopkins University
Charles and 34th Streets
Baltimore, MD 21218

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Dr. Ward Edwards
Director, Social Science Research Institute
University of Southern California
Los Angeles, CA 90007

Dr. Charles Gettys
Department of Psychology
University of Oklahoma
455 West Lindsey
Norman, OK 73069

Dr. Kenneth Hammond
Institute of Behavioral Science
University of Colorado
Room 201
Boulder, CO 80309

Dr. James H. Howard, Jr.
Department of Psychology
Catholic University
Washington, D.C. 20064

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Rice University
Houston, TX 77001

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University of Illinois
Department of Psychology
Urbana, IL 61801

Dr. Richard W. Pew
Information Sciences Division
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02238

Dr. Hillel Einhorn
University of Chicago
Graduate School of Business
1101 E. 58th Street
Chicago, IL 60637

Dr. John Payne
Duke University
Graduate School of Business Administration
Durham, NC 27706

Dr. Baruch Fischhoff
Decision Research
1201 Oak Street
Eugene, OR 97401

Dr. Andrew P. Sage
University of Virginia
School of Engineering and Applied Science
Charlottesville, VA 22901

Dr. Leonard Adelman
Decisions and Designs, Inc.
8400 Westpark Drive, Suite 600
P. O. Box 907
McLean, Va 22101

Dr. Lola Lopes
Department of Psychology
University of Wisconsin
Madison, WI 53706

Mr. Joseph G. Wohl
Alphatech, Inc.
3 New England Industrial Park
Burlington, MA 01803

Dr. Rex Brown
Decision Science Consortium
Suite 721
7700 Leesburg Pike
Falls Church, VA 22043

Dr. Wayne Zachary
Analytics, Inc.
2500 Maryland Road
Willow Grove, PA 19090

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